Vol. 6 No. 9

TORREYA

September, 1906

TUBER-FORMATION IN SOLANUM TUBEROSUM IN DAYLIGHT

By C. Stuart Gager

Thomas Andrew Knight, writing in 1829 to Dr. Bevan, said:* "I have been and am still engaged in some experiments on the potato, which plant has given me more physiological information than all the remainder of the vegetable world; and where it has not given me the information I wanted, it has directed me where to find it."

It is too well known to need statement here, that the potato tuber is a branch, modified as an organ for the storage of food, and resulting from the thickening of stolons that arise from the basal parts of the main axis. This homology was recognized by Knight as early as 1801, and was later demonstrated by Turpin † in 1828.

By an ingenious contrivance, Knight ‡, in 1806, succeeded in growing potato plants so that only the fibrous roots penetrated the soil. By preventing the formation of tubers on the stolons that normally would have developed underground, and also on the lateral branches of the aërial portion of the shoot, he succeeded in getting the plants to form tubers at "the extremities of the branches, those being the points most distant from the earth,

* A selection of the physiological and horticultural papers of T. A. Knight, p. 63, London, 1841.

† Turpin, J. F. Mémoire sur l'organisation intérieure et extérieure des tubercules du Solanum tuberosum et de l'Helianthus tuberosus, considérée comme une véritable tige souterraine, et sur ces tiges. Mémoires du Muséum d'Histoire Naturelle. Read Dec. 27, 1828.

‡ Knight, T. A. On the inverted action of the alburnous vessels of trees. Phil. Trans. 96 : 293. 1806.

[No. 8, Vol. 6, of Torreya, comprising pages 157–180, was issued August 25, 1906.]

in which the tubers are naturally deposited." "Many of the joints of the plants during the experiment became enlarged and turgid; and I am much inclined to believe," he states, "that if I had prevented the formation of regular tubers, these joints would have acquired an organization capable of retaining life, and affording plants in the succeeding spring." So far as the writer has been able to ascertain, this records the first successful attempt to secure experimentally the formation of potato tubers in the light, and is the first record that tubers can, under any circumstances, form on the aërial portions of the shoot.

On another variety of potato, as soon as tubers began to form normally, Knight nearly detached many lateral aërial branches, leaving them connected only by enough "alburnous and cortical fibres and vessels as were sufficient to preserve life." After this treatment small tubers formed in the light at the base of the leaves of the depending branches. This experiment was one of many, performed by the same keen observer and thinker, to prove that sap may pass down in plants, and that the descending current, though normally passing through the bark, as he had previously demonstrated,* may, under certain circumstances, travel downward through the alburnum, or sap wood.

Three years later †, Knight succeeded in producing experimentally "a profusion of blossoms" from the buds of the potato tuber. By destroying the above-ground branches he also induced the under-ground stem parts to depart from their habit and grow up into the air and light. From these experiments he was led to the conclusion that the runners on which the potato tubers are formed, "are very similar in organization to the stem of the plant, and readily emit leaves and become converted into perfect stems, in a few days, if the current of ascending sap be diverted into them; and the mode in which the tuber is formed above, and beneath the soil, is precisely the same."

It is fortunate for agriculture that some of Knight's later conclusions are not wholly correct, else planting would, indeed, be

*Knight. Account of some experiments on the descent of sap in trees. Phil. Trans. 93: 277. 1803.

†Knight. On the origin and formation of roots. Phil. Trans. 99: 169. 1809.

a most laborious proccess, for in 1822 he states * that the potatoes, being "shoots, or branches, which have grown thick instead of elongating," gardeners should take pains to plant the tubers right side up with care, as they "retain the disposition of branches to propel their sap to their leading buds, or points most distant from the stems of the plants, of which they once formed parts."

In this same paper he describes another experiment, in which he planted seed tubers above the soil so that only the fibrous roots growing from them entered the ground. Then, by removing all blossoms and runners that appeared, he secured "a numerous crop of young tubers," growing sessile at the buds or "eyes" of the old.

Moretti † describes a modification of one of the experiments performed by Knight in 1806. By cutting a potato stem near its base so that the upper portion is joined to the root end only by means of a small strip, nourishment was prevented from being translocated to the tuberiferous stolons. Under this condition tubers formed in the leaf axils along the branches exposed to light.

In more recent years de Vries is said by Vöchting to have secured the formation of tubers by *Solanum tuberosum* in the light, but the original paper ‡ has not been accessible to the writer.

The most recent and most extensive experiments on tuberization are by Vöchting.§ He did not succeed in securing the formation of tubers in the light in all varieties, but in the variety "Saucisse," while the main stem never developed tubers in the light, its side branches may become transformed into tubers under such conditions. In his later experiments Vöchting ||

* Knight. An account of an improved method of raising early potatoes in the open ground. Trans. Hort. Soc. London, 4 : 447. 1822.

† DeCandolle, A. P. Pflanzen-physiologie. Stuttgart und Tübingen, 1833. DeCandolle quotes Moretti et Guieciardi, De nonnullis physiologico-botanicis animadversionibus. 1831.

‡ DeVries, H. Beiträge zur speciellen Physiologie landwirtschaftlicher Kulturpflanzen. Landwirth. Jahrb. 7 : 19, 217, 591, 659. 1878.

§ Vöchting. Ueber die Bildung der Knollen. Bibliotheca Botanica, 1⁴. 1887; Zur Physiologie der Knollengewächse. Leipzig, 1899. Also in Jahrb. Wiss. Bot. 34 : 108. 1900; Ueber die Keimung der Kartoffelknollen. Bot. Zeit. 5 : 87. 1902.

|| *l. c.* 1902.

secured good tubers on aërial branches in the dark, but only unusually fleshy sprouts in very diffuse light.

The accompanying illustration (FIGURE 1) is from a photograph of a specimen found growing in the conservatory of the New York Botanical Garden. It is customary here, as in many greenhouses, to place pieces of "potato" on the soil of the potted plants to protect the plant from snails and slugs. The potato, being more accessible, is eaten and the plant spared.

FIG. 1. *Solanum tuberosum.* Tuber-formation on aërial shoot in light.

In the humid atmosphere of the glass house these pieces of potato readily sprout, and a few weeks ago the specimen here illustrated was found, growing in sufficient light to develop abundant chlorophyll in the cortex.

The entire specimen, including the piece of the seed tuber, had been constantly above the surface of the soil, and exposed to rather strong illumination. As will be seen from the picture, the sprout that bears the new tuber sprang from an "eye" near the apical end of the seed-tuber, and is somewhat abnormally short and fleshy. A few of the leaves at the nodes of the young green tuber show a slight differentiation into petiole and blade,

and from the axil of one of these leaves a sprout, about 5 mm. long, has developed. The tuber itself is about 25 mm. long and 20 mm. wide at the thickest part.

This specimen is instructive, not only as a unique demonstration of the stem nature of the "potato," but also in connection with a recent theory that potato tubers are caused by a fungus. It is known that a species of fungus, a *Fusarium*, is endotrophic with *Solanum tuberosum*, and the question has been raised by Bernard * as to whether or not the tubers are an effect of this fungus, and dependent upon it for their formation. Jumelle † infected soil artificially with a species of *Fusarium*, and planted in the infected soil *S. Commersoni*, a species that forms only small and few tubers. A control planting was made in sterilized soil. The infection produced no constant results, however, with *Solanum Commersoni*, and contradictory results with varieties of *S. tuberosum*. In the case of the "Early Marjolin" variety, association with the fungus was accompanied with increased tuberization, while the opposite result was obtained with the "Géant de Lyon" variety.

The formation of a tuber in the air and light, therefore, is of interest as showing that tuber-formation may take place under conditions in which the *Fusarium*, in all probability, does not enter as a factor.

Of potato tubers Goebel ‡ says: "They are nothing else then than leaf-shoots which on account of their position in the whole shoot-system of the plant have become accustomed to an underground life, and subsequently under the influence of the material supplied from the aërial leafy shoots have become transformed into tubers." The phenomenon is an illustration of what Goebel calls "qualitative correlation."

It is instructive to recognize just what has taken place in the present anomaly. If we disregard the small amount of photosynthesis that may have occurred, owing to the slight develop-

* Bernard, Noël. Études sur la tubérisation. Rev. Gén. de Bot. 14 : 139, 269. 1902.

† Jumelle, Henri. De l'influence des endophytes sur la tubérisation des Solanum. Rev. Gén. de Bot. 17 : 49. 1905.

‡ Goebel, K. Organography of plants. Eng. trans. by Balfour, 1 : 215. 1900.

ment of chlorophyll in the cortex of the new tuber, the metabolic changes have been accompanied by no increase of substance. On the contrary, it is probable that, owing to respiration, the dry weight of the parts is less than that of the original piece of tuber.

Part of the food elaborated and digested in the leaves of the parent plant was translocated to the tuber of which the piece in FIGURE 1 was a part. After the portion in question was cut off and placed in the conservatory this stored food began to be redigested and translocated to the developing "eye" or bud. There has been, then, merely a transfer of substance from the cells of the old tuber to the cells which ultimately developed the new.

Normally this awakened bud would presumably have given rise to an aërial leafy branch. The causes of its development into a tuber are difficult to recognize. Environmental conditions were not such as have favored tuberization in recorded experiments, and internal causes are still more difficult to assign.

NEW YORK BOTANICAL GARDEN,
July 13, 1906.

A NEW CHESTNUT DISEASE*

BY WILLIAM A. MURRILL

A new and very serious disease of our native chestnut is epidemic in many parts of New York City and threatens to destroy practically all the chestnut trees in this vicinity. A field survey has not yet been undertaken, but the disease is known to occur also in New Jersey, Maryland, the District of Columbia and Virginia.

An investigation of the disease was begun at the New York Botanical Garden nearly a year ago, and most of the facts regarding it are now in our possession. Pure cultures of the fungus

* Murrill, W. A. A serious chestnut disease. Jour. N. Y. Bot. Garden 7 : 143–153. *f. 13–19.* June, 1906.

Merkel, H. W. A deadly fungus on the American chestnut. Ann. Rept. N. Y. Zoöl. Society 10 : 97–103. July, 1906. [Illust.]

Murrill, W. A. Further remarks on a serious chestnut disease. Jour. N. Y. Bot. Garden 7 : 203–211. *f. 25–30.* September, 1906.